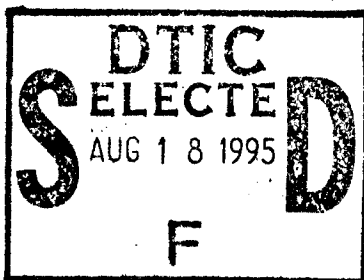


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RECORDING TYPE AUTOMATIC GEIGER TUBE CALIBRATOR



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By G. J. Crits and G. C. Newlin

ABSTRACT

Before a Geiger tube can be used, it is necessary to calibrate it or plot a curve showing its plateau of operation. This report describes a means of plotting the plateau of a Geiger tube automatically.

* * * * *

The Geiger-Mueller tube counter operates by the production of an electrical discharge in a gas. The counter is extremely sensitive, and a discharge may be produced when a single ion pair is produced almost anywhere within the tube. It is distinguished from other discharge counters by the large volume over which the formation of an ion pair will produce a discharge.

It is highly impossible to guarantee that a counter, carefully made to any specification, will be satisfactory in all respects. The extreme sensitivity of the counter renders it liable to apparently spontaneous discharges, the origin of which is uncertain. Furthermore, the characteristics of the discharge are also often found to change with time.

Suppose, for the present, the growth and subsequent extinction of the discharge are taken for granted. Evidence about the initiation of the discharge is mainly obtained from characteristic curves of the types shown in Figure 1 which shows the number of discharges per minute plotted against the voltage applied to the counter under the action of a constant weak source of ionization.

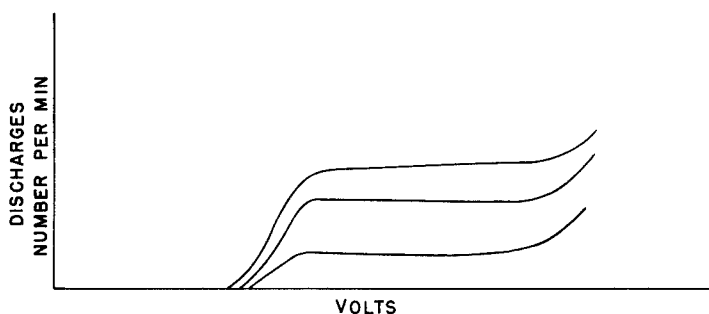


Figure 1. Number of discharges per minute plotted against voltage applied.

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The various curves of Figure 1 refer to ionization sources of different strength. They have the form which is claimed to be the ideal characteristic for a Geiger-Mueller counter. As the voltage is increased, the number of counts is first zero, then rises steeply to a flat portion where the rate of counting is independent of the voltage.

After construction and evacuation of a Geiger-Mueller tube, it has to be calibrated. The standard method of calibrating a Geiger-Mueller tube employs a known radioactive source, a scale of 64, a variable power supply and a stop watch. As stated earlier, the Geiger-Mueller tube works on a flat plateau. To find this plateau, the power supply is changed in different voltage steps and counts are taken for a predetermined time. A curve is then drawn with the number of counts per minute plotted against the voltage change. This method of calibrating requires a technician's full time to take readings and plot a curve for each tube.

An automatic Geiger-Mueller tube calibrator has been designed which makes it possible to relieve the investigator of the tedious recording and calibrating job. The recording type AGTC (Automatic Geiger Tube Calibrator) will plot the calibration of a tube in a series of 10 to 15 voltage steps (see Figure 2). The length of time is predetermined for each step between 0 and 60 seconds by the employment of an adjustable timer. The voltage differences on the Geiger tube are obtained by setting the scaler voltage to a fixed high value (lead to center electrode of Geiger tube) and applying to the shell of the Geiger tube a variable (in 20 volt steps) plus voltage from a voltage regulated power supply. Each step represents a different successive voltage as indicated by the difference of scaler and controller voltage. The height of the steps indicate the counting rate which will be essentially constant on the plateau.

The operation of the AGTC is relatively simple. To start the operation, it is necessary to press a button; at the end of the calibration, the counter will stop automatically unless it is required to start another calibration of the same tube or of another tube. A safety circuit is also provided to shut off the AGTC when the counting rate increases above the normal operating range.

The following equipment is required:

1) A scaler and counting rate circuit. The scaler and counting rate circuit used are modified slightly from the Model 400 scale of 64 designed by the Electronics group.

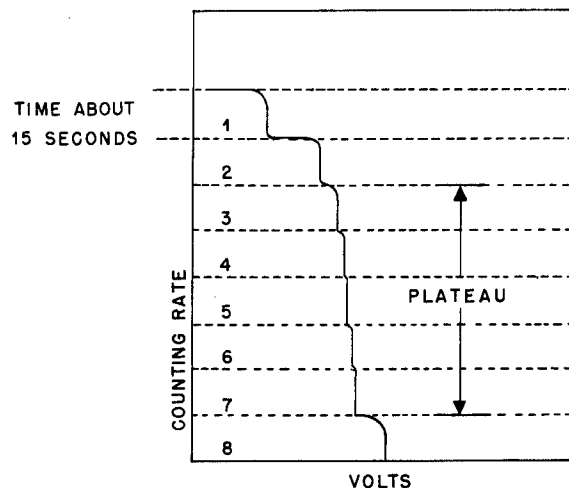


Figure 2. Plot showing calibration of tube in a series of 10 to 15 voltage steps.

The scaler modifications are principally in the provision of a R F high voltage power supply with a safety relay for guarding against high counting rate, and the following leads or sockets:

- a) Leads to recorder
 - b) High voltage to AGTC controller and ground
 - c) Safety relay switch leads
 - d) 110-volt power lead
- 2) An AGTC controller consisting of the following relays and devices:
- a) Timer, adjustable from 0 to 1 minute, and associated relays.
 - b) An 11-step relay covering 200 volts in ten 20-volt steps; the extra step being used to stop the calibration.
 - c) A reset relay used to stop and start the calibration and as an on-off switch in the high voltage circuit of the tube.
 - d) A delay relay, adjustable type, used to allow a mechanical arm (spring return) of the timer to return to starting position.
 - e) Other relays used for making and breaking circuits in associated equipment.
- 3) A power supply (for example, the Model 50 designed by the Electronics group) provided with a meter to indicate voltage steps.
- 4) A recording microammeter (GE or equivalent) 10 or 100 microamperes, depending on the output of the counting rate meter. The paper trace should be at the rate of about 2 min/div. An electrically driven recorder is preferable inasmuch as it can be easily shut off at the end of the calibration run.

The advantages of the AGTC are:

- 1) Permanent visible record.
- 2) Automatic safety switch device for protection against high counting rate which may be incorporated in any counter.
- 3) Technician's full time unnecessary.

For a more detailed description of the AGTC refer to Figure 3, a block diagram, and Figure 4, a schematic diagram.

As shown in Figure 3, the center electrode of the Geiger tube is connected to the Model 400 scaler and the R F high voltage supply. We will assume that the R F high voltage supply is at 1500 volts. The shell of the Geiger tube is connected directly to step relay which gives a voltage change of 20 volts for each step up to 200 volts. The voltage is supplied by the Model 50 power supply with a bleeder in its output tapped at every 20 volts. The output of the Model 400 scaler is connected directly to the stepping relay of the AGTC for recording on ten registers. Timer and relay assembly for control and operation will be explained in more detail in the description of Figure 4.

Figure 4 is a schematic diagram of the AGTC with connections to associated equipment. Starting with relay 1, a normally open relay is not actuated until a momentary contact is made by pressing push button F. The activation of relay 1 closes the contacts, activating relay 7 which is a step relay, and at the same time actuates relay 4. Also, when push button F is pressed, a lock on relay 2 is released allowing its contacts to close. With the contacts made on relay 2, continuity is made between the high voltage of the scaler and the Geiger tube as shown by H and H. On the same relay, a separate pair of contacts are closed connecting one side of the 110 volts, through contacts on relay 3, to the industrial timer 6 activating it when the contacts on relay 2 remain closed through the calibration of the Geiger tube, except for the last step which will be explained later.

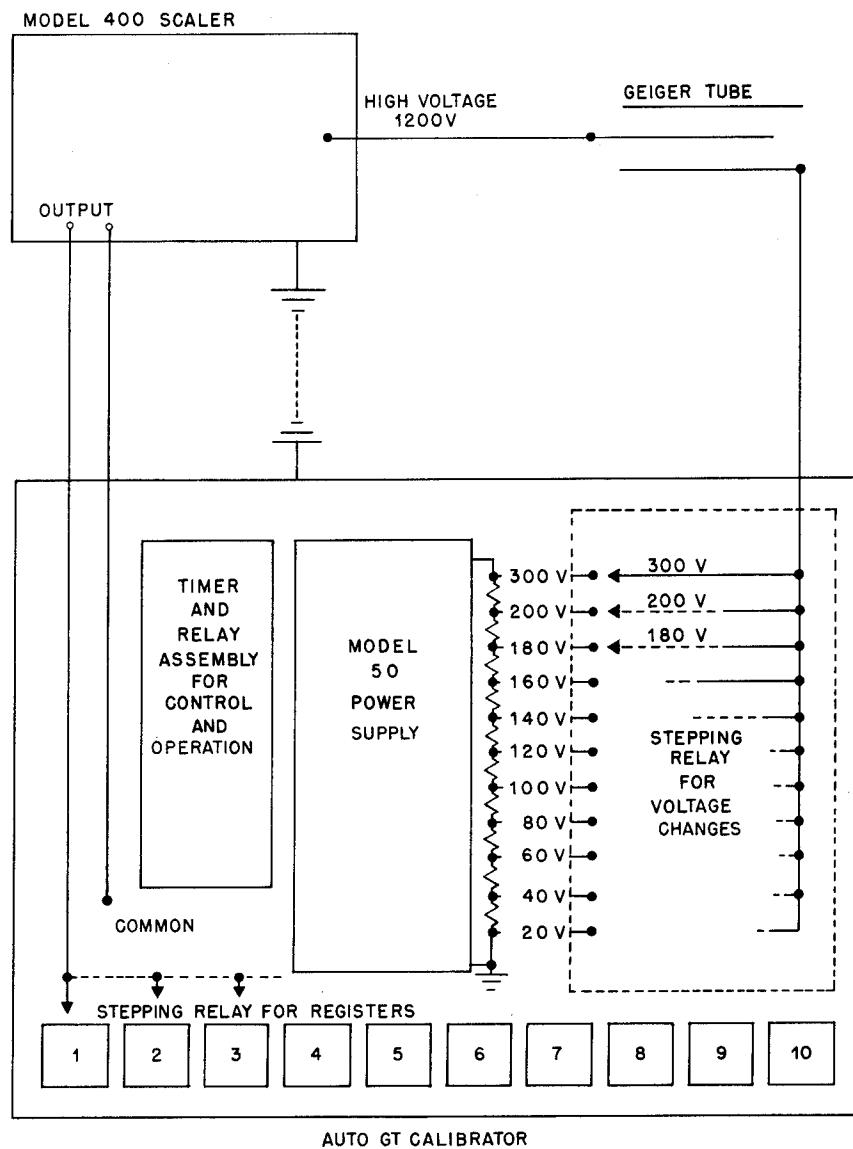


Figure 3. Block diagram of automatic Geiger tube calibrator.

Relay 3 is actuated by the time delay relay 5 which can break the connection to the industrial timer for a short time allowing contact arm to return to its original position. Relay 3 also starts and stops a General Electric paper drive recorder (indicated by M) which may be either 10 or 100 microamperes.

Relay 4 is momentarily actuated for each change in the step relay, breaking its contacts and taking the potential off of relay 5 allowing its contacts to close and actuating relay 3 which has been explained.

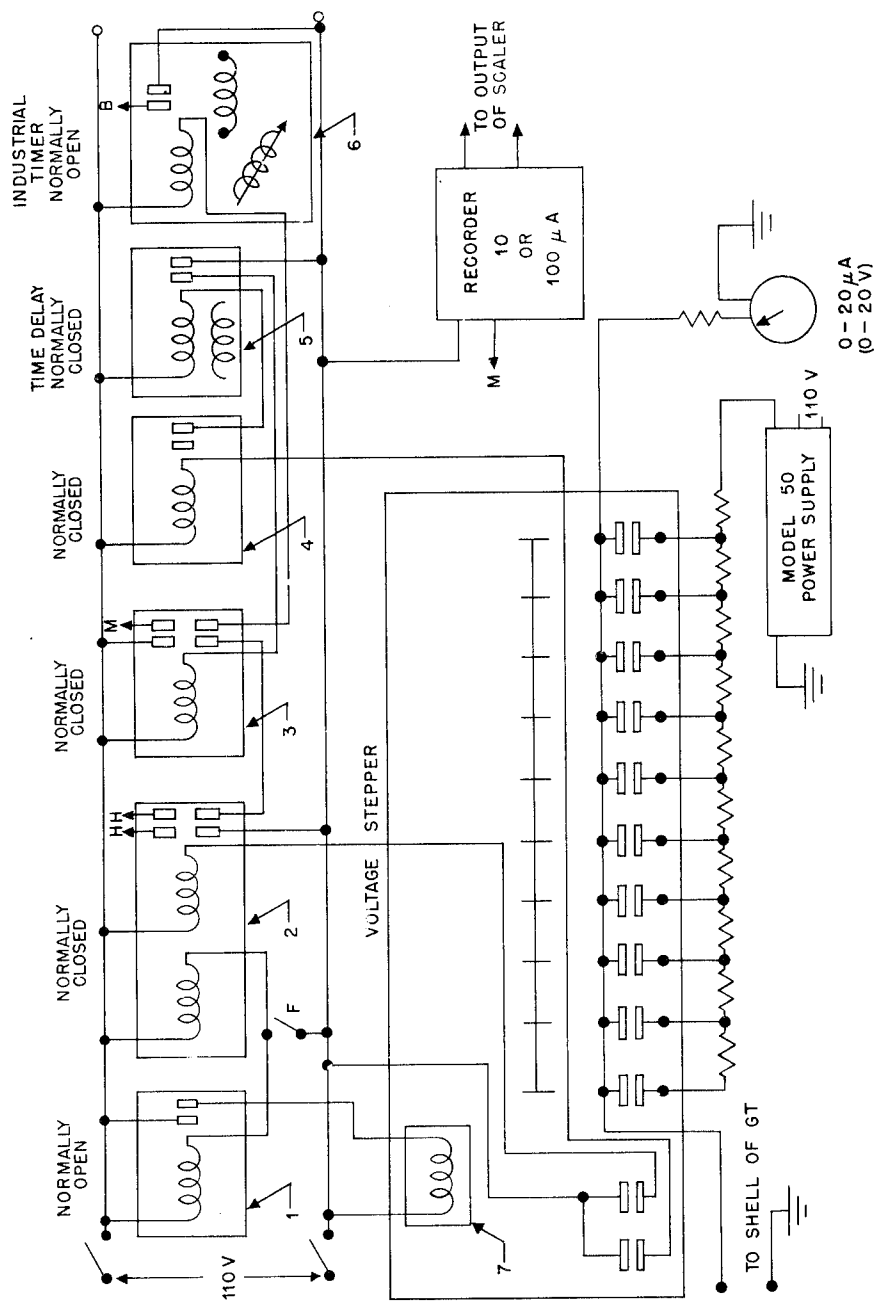


Figure 4. Schematic diagram of automatic Geiger tube calibrator.

Relay 6, an industrial timer, can be set before making contact, from 0.5 minute to 5.5 minutes. The relay contacts are connected to the same points as push button F. The timer is set for a predetermined time allowing readings to be recorded in this time. At the end of the predetermined time, the contacts are made actuating relay 1.

Relay 7 is an 11-contact step relay with one set of contacts on the driver relay. When the push button F is pressed, the step relay assumes its first position. For the following 10 steps, it is actuated by relays 6 and 1. A Model 50 power supply with a 300-volt output is connected across relay 7 which has a resistor between each step from 1 to 10 to give a voltage step of 20 volts for each advance step. The voltage steps are taken through a connector to the shell of the Geiger tube. A meter is employed to read directly each voltage step. Contact 11, the last step relay, makes contact activating relay 2 allowing a lock to keep its contacts open. When the contacts of relay 2 open, the industrial timer will no longer operate and the high voltage is broken between the Geiger tube and the Model 400 scaler.

A safety relay is employed in a counting rate circuit which, when closed, will actuate relay 2 and also stop the operation. The safety relay is employed to stop the operation when the counting rate increases above the normal operating range.

The instructions for operating the AGTC are:

- 1) Connect leads to the Geiger tube.
- 2) Connect leads to output of scaler.
 - a. High voltage lead from scaler to center of Geiger tube.
 - b. Low voltage lead from AGTC to shell of Geiger tube.
- 3) See that all associated equipment is connected to its proper terminals.
- 4) Set scaler voltage to fixed value (depending on type of Geiger tube and the voltage range expected), such as 1000 or 1200 volts.
- 5) Set industrial timer for period of counting desired.
- 6) Read and record values on the ten registers of the AGTC.
- 7) Press starting button on AGTC, which starts the process and continues through for a 200 volt calibration, and then stops automatically.

Referring to Figure 5, a set of two curves with scale of 64 counts versus voltage, have been plotted from a Geiger tube. The curve indicated by a solid line was plotted by the old method (hand calibrated). The curve indicated by the dotted line was plotted from the AGTC in two separate operations.

DISCUSSIONS

Errors and Stability

1) Counting errors. The timer inconsistencies offer an error of 1 (X64) count if the timer is off 1 sec (if the counting rate is about 60 (X64) per minute). Another error of 1 (X64) count may be obtained by not having the scaler reset after each counting period. (This resetting is possible to do, but means adding extra leads to scaler). The addition of errors will give a total error of 2 (X64) counts which when compared to a total count of not less than 150 (X64) is acceptable.

2) Voltage stability. The voltage stability of the Model 50 power supply is very good. The voltage will not vary more than a couple volts. Voltage stability of the scaler is fairly good (especially if a R F power supply exists), but drifts are sometimes noticed.

3) Stability of AGTC. In spite of the many relays existing in this unit, only one relay (the delay relay) and the timer with its relay are actually energized while counting. All others are momentarily energized. The AGTC has been operated several dozen times with failure or relay jamming occurring only once. (Springs of relays should be adjusted).

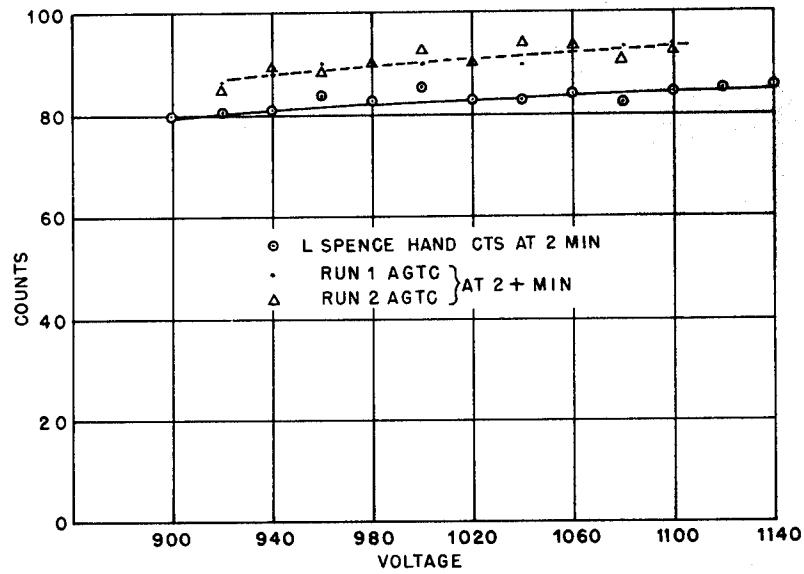


Figure 5. Two curves with a scale of 64 counts versus voltage.